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UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Research Administration
Bureau of Entomology and Plant Quarantine

A HOPPER AND MECHANISM FOR DISTRIBUTION OF BAITS AND DUST BY AIRPLANES FOR INSECT CONTROL

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Outbreaks of grasshoppers, Mormon crickets, and white-fringed beetles in recent years have emphasized the need for adapting airplanes or autogiros to spread baits and insecticide dust in large-scale pest-control programs of emergency nature. While the most improved ground distributing machines have rendered excellent service, the extensive areas requiring application, the ruggedness and inaccessibility of considerable portions of the terrain, the urgency of the need for immediate application, and the necessity for economy of operation prompted the development of airplane hoppers and distribution mechanisms for application of such materials.

Airplanes adapted for crop dusting were tested for these purposes, and it was determined that they could be used to advantage if a mechanism could be designed that would distribute materials without clogging or tunneling and spread them in an even and uniform swath.

The baits consisted of bran, sawdust, water, and insecticides, which were very difficult to distribute because of a tendency to pack and tunnel over the revolving agitators in the standard type of hopper employed for cotton dusting. The cryolite dust used for the control of white-fringed beetles also gave the same trouble as the wet baits.

In order to control the number of pounds of bait distributed per acre, the opening on the bottom of the hopper of the cotton dusters was adjustable so that the flow of materials could be regulated by decreasing or increasing the size of the aperture. This sometimes caused clogging, was difficult to adjust to an even flow, and contributed to mechanical breakdowns and loss of time. It was necessary, therefore, to redesign the mechanism or to construct devices which would eliminate the shortcomings of existing equipment. The latter course was considered to be more practical.

Mechanical Principles

Preliminary consideration of various adjustable mechanical devices designed to apply baits or dusts from airplanes suggested the adaptation of certain essential principles without structural changes in the plane, including (1) a hopper, with smooth walls as perpendicular as practical to permit materials to settle to the bottom, from which they would be fed out in application; (2) an endless drag-link chain conveyor, the effective portion of which would revolve over the false bottom of the hopper upon which the materials bear, to withdraw desired amounts by means of suitably sized and spaced angle-metal bars, connecting the drive chains, spaced apart the full width of the hopper; (3) an opening, or throat, with an adjustable door at the lower front of the hopper, through which the conveyor would deliver desired amounts of materials; (4) an open-ended enclosure or venturi tube parallel to the airflow, beneath the hopper and below the fuselage, into which materials would be delivered through the hopper door (controlled by the pilot from the cockpit) and from which they would be driven by the rush of air beneath the plane and distributed in its wake; and (5) an outboard wind-driven propeller, adequate to furnish power to operate the distribution mechanism through a reduction gear, with a brake controlled from the pilot's seat.

These principles have been incorporated in the described construction and are set forth in the attached drawings, which show the installation, mountings, and relative position of the component parts. Specifications and a list of materials necessary for the construction of the various parts are hereinafter presented.

Appropriate dimensional alterations would permit adaptability of this type of hopper and distribution mechanism to any plane or autogiro, depending on its size, design, load capacity, speed, and other factors. The hopper described herein is of 29 cubic foot capacity for installation in a biplane powered by a 285 horsepower engine with cruising speed of 90 miles per hour, and which will carry a pay load of 984 pounds on the take-off.

Mounting of Hopper Unit

The hopper is mounted between the fire wall and cockpit, taking the place of the front cockpit, at the center of gravity of the plane, as shown in drawing 3. The center of gravity varies with different types of airplanes. To insure safety in flight and permit licensing of the craft by the proper authorities, the hopper should be installed by persons thoroughly acquainted with the mechanics of aircraft.

The hopper is attached to the top longerons by means of 1½-inch aluminum alloy tee sections, and the bottom rests on the lower fuselage members with wood strips between, which thereby clamp the hopper and conveyor unit to the lower fuselage members as shown in drawings 3 and 5.

The hopper is constructed of .065-inch 2 SO aluminum and is bolted to the top cowling of the same material, which forms part of the hopper, as shown in drawings 1 and 2.

The power unit, including the small propeller and reduction gear, is mounted on a bracket which extends from the lower longeron to the top longeron and is connected to the outside of the fuselage by clamping the bracket to the longerons, the latter being protected with 1½-inch wood blocks and 1/16-inch wood strips between the clamps and members, as shown in drawing 4.

There are no parts of the hopper construction attached to the fuselage without intervening wood or rubber to protect the fuselage members.

The hopper is so installed that, as the weight of its contents changes, the center of gravity is still within the range for which the airplane is approved.

Specifications for Hopper Unit Construction and Installation

Hopper.--Hopper to be made of .065-inch 2 SO sheet aluminum, taking advantage of all suitable space in the fuselage, the bottom of the hopper to be approximately the width of the bottom of the inside of the fuselage (drawings 1 and 4). Hopper to have an adjustable door directly over the outlet end of the drag-link conveyor so as to regulate the amount of material fed by the conveyor (drawing 3). Hopper to be dustproof. Hopper walls to be supported with 1½- by 1/8-inch angle aluminum alloy braces (drawings 1, 3, 4, and 5). The hopper door to be 27 by 37 inches and constructed of .065-inch 2 SO sheet aluminum (drawing 2). The cowling to be well braced around the door (drawing 2).

Drag-link conveyor.--As shown in drawings 6 and 7. The drag links to be of 1/2 by 1-inch 17S-T angle aluminum alloy, spaced 4 inches apart. The conveyor chain to be No. 32 malleable iron, complete with right and left A-1 attachments. The conveyor to be as near as possible the full width of the bottom of the hopper (drawings 6 and 7) and driven by four No. 32 eight-tooth sprockets mounted on 3/4-inch shafting. Sprockets to be turned down and made as light as possible. Shafting to be supported by dustproof rubber

pillow block ball bearings, 3/4-inch, which should be mounted so that adjustments can be made on the drag-link conveyor (drawings 6 and 7). Felt washers to be mounted between bearings and conveyor box. Conveyor box to be made of .065-inch aluminum braced with 1¼-inch aluminum alloy. The hopper floor under the endless drag-link top chain, as shown in drawing 6, to be made of .091-inch aluminum alloy with a 1¼-inch tee section of the same material for support. The conveyor unit to be bolted to the bottom of the hopper, thereby clamping the hopper and conveyor unit to the lower fuselage members, as shown in drawings 3 and 5. Fuselage members to be protected by wood, fabric, or rubber. The hopper door to be full width of hopper with an opening of at least 6 inches. Door to be made of .187-inch 2 S 1/2 H sheet aluminum. Door to be dustproof when closed (drawings 6 and 7).

Venturi tube.--The venturi tube to be adjustable and full width of conveyor box. Tube to be made of .064-inch 17S-T aluminum alloy, well braced with 1/2-inch channel iron (drawings 1, 3, and 4).

Power unit.--Power to be provided by an 18-inch (overall) propeller, connected to 48 to 1 gear reducer, mounted on side of fuselage. A brake to be mounted on propeller. Lining and brake drum to be 1 inch in width. Brake to be connected by a 3/16-inch cable to the hopper door control. Twelve-tooth, No. 41 sprocket to be mounted on drive shaft of reduction-gear box. The 24-, 30-, and 45-tooth No. 41 sprockets are to be used for varying speeds on the drag-link conveyor shaft (drawings 2 and 4). The gear box mounting bracket to be clamped to the top and lower longeron (drawing 4).

Controls.--Controls for hopper door and propeller brake to be installed in cockpit accessible to the pilot (drawing 3).

Fuselage and wings.--All openings and outlets, such as those where controls and cables enter fuselage and wings, should be covered or protected by socks to prevent the entry of dust into cockpit or interior of wings.

List of Materials

Hopper Unit

1	72" x 36" x .039"	2 SO sheet aluminum
2	60" x 36" x .065"	2 SO sheet aluminum
2	72" x 36" x .065"	2 SO sheet aluminum
2	48" x 36" x .065"	2 SO sheet aluminum
1	36" x 28" x .065"	2 SO sheet aluminum
1	20' x 1½" x 1/8"	Aluminum alloy T section
2	20' x 1¼" x 1/8"	Angle aluminum alloy
1	6' x 1"	Aluminum hinge
2	12' x 2½" x .091"	2 S 1/2 H aluminum alloy sheet
1	15' x 1/2"	Channel aluminum
660	1/2" #8-32 cadmium-plated bolts and nuts	
200	3/4" #10-32 cadmium-plated bolts and nuts	
1	25' of 3/4" channel rubber edging	
3	Automobile hood hooks or trunk latches	

Conveyor Unit

1	27" x 9" x 3/16"	Aluminum alloy plate
1	48" x 48" x .065"	2 SO sheet aluminum
4	10' x 1¼" x 1¼" x 1/8"	Aluminum alloy angle
1	24" x 26" x .091"	2 S 1/2 H sheet aluminum alloy
2	12' x 1" x 1/2" x 1/8"	Aluminum alloy angle
4	8-tooth #32 sprockets	
1	10' #32 malleable detachable chain	
20	A-1 R attachments for #32 chain	
20	A-1 L attachments for #32 chain	
5	3/4" rubber pillow block ball bearing	
4	#3 tapered pins	
50	3/16" x 3/4" aircraft bolts and castle nuts	
30	3/16" x 1" aircraft bolts and castle nuts	
1	8" x 26" x 3/16"	Aluminum alloy plate
200	#10-32s cadmium-plated bolts and nuts	
1	30" x 3/4" O. D. x 3/32" wall thickness aircraft steel tubing	
1	44" x 3/4" O. D. cold-rolled shafting	

Power Unit

1	48 to 1 gear reducer
1	18" overall wood propeller; 2 blade
1	12' x 3/16" flexible cable
1	3' x 1" x 3/32" Molybdenum steel
1	Stub shaft to be made to hold propeller on gear box drive
1	4" x 1" flat pulley for brake drum

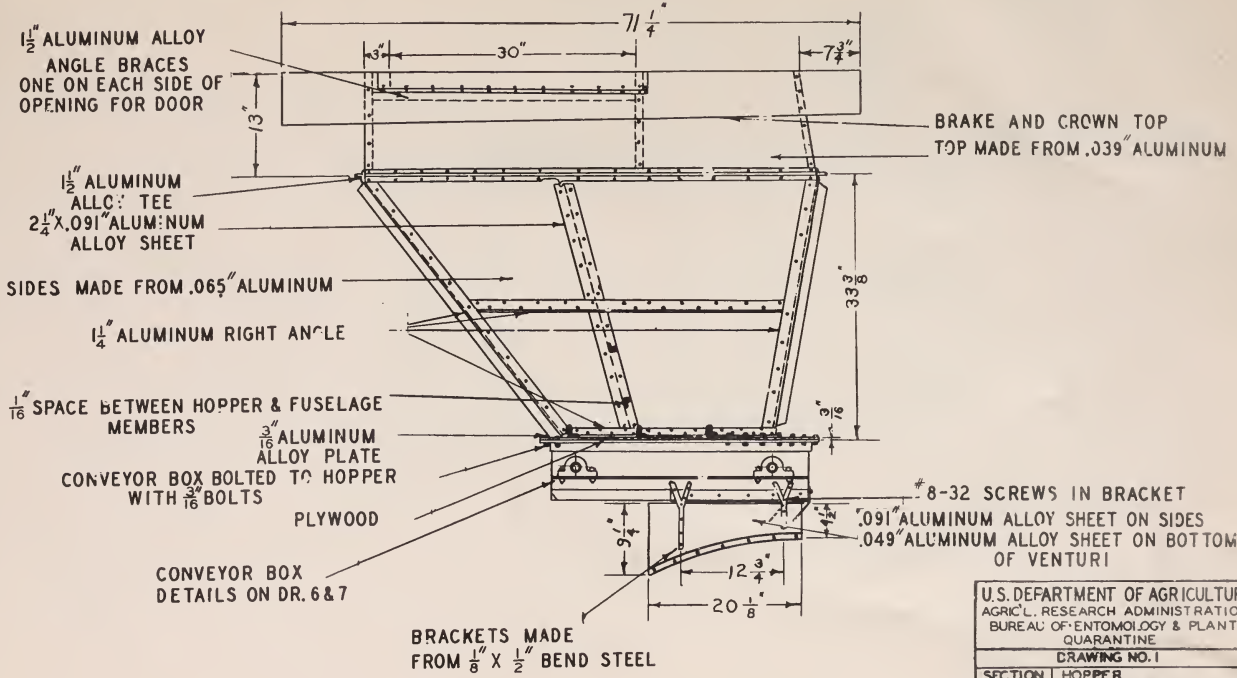
Power Unit (Continued)

1	12" x 1" steel brake band
1	12" x 1" brake lining
1	12' x 1$\frac{1}{2}$" x .035" streamlined seamless steel aircraft tubing
1	3/16" plate 6" x 6" to hold brake assembly
4	1/2" x 1$\frac{1}{2}$" bolts and nuts
1	12-tooth sprocket #41 - 7/8" bore
1	24-tooth sprocket #41 - 3/4" bore
1	30-tooth sprocket #41 - 3/4" bore
1	45-tooth sprocket #41 - 3/4" bore
1	6' #41 roller chain
1	Half link for #41 roller chain
1	Connecting link for #41 roller chain

Venturi Tube and Control

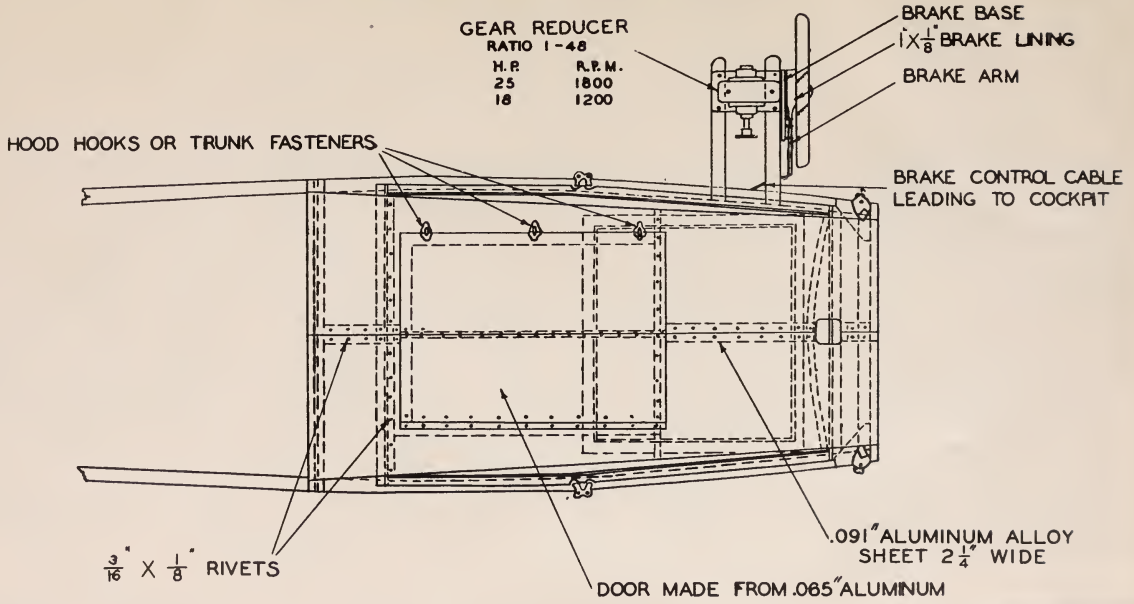
1	24" x 26" x .049" . . . . . 2 S 1/2 H aluminum alloy sheet
1	48" x 12" x .091" . . . . . 2 S 1/2 H aluminum alloy sheet
$\frac{1}{2}$	lb. aluminum rivets - 3/32" x 1/4"
1	4' x 1/8" x 3/4" strap iron
1	9' x 3/4" x .065" wall - aircraft tubing
1	12' x 5/8" x .065" wall - aircraft tubing
5	1/4" x 3/16" clevis and pins
1	Rubber handle grip
30	1" #8-32 aircraft bolts and nuts
1	Aircraft pulley - 2" x 17/64"
1	4$\frac{1}{2}$" turnbuckle
4	3/8" tie rod terminals - threaded clevis type

SIDE VIEW OF HOPPER



U.S. DEPARTMENT OF AGRICULTURE AGRIC'L. RESEARCH ADMINISTRATION BUREAU OF ENTOMOLOGY & PLANT QUARANTINE	
DRAWING NO. 1	
SECTION	HOPPER
AIRCRAFT	STANDARD 285 H.P.
ORIGNAL DR. BY C.N.H.	DATE: 3-40
REVISED BY C.N.H.	DATE: 12-40
TRACING BY H.H.W.	DATE: 8-17-42

TOP VIEW OF HOPPER IN FUSELAGE



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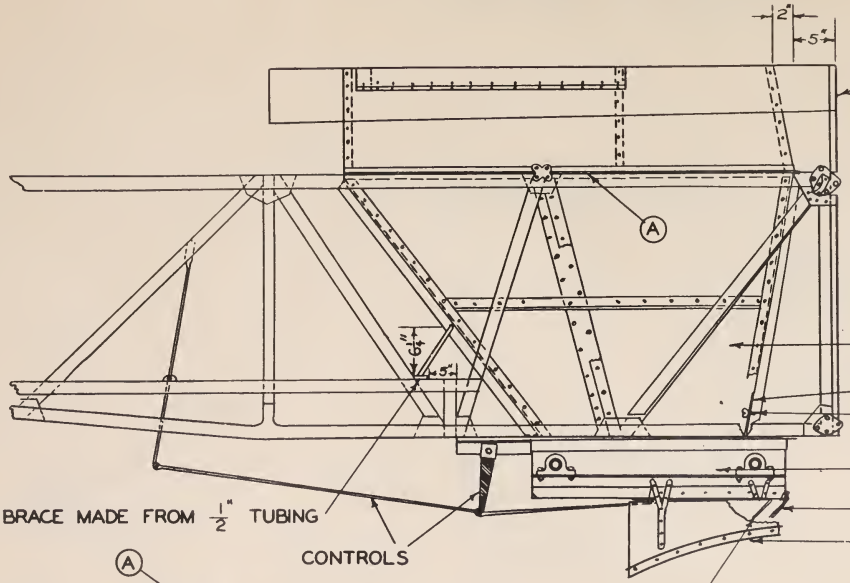
SECTION	HOPPER
AIRCRAFT	STANDARD 285 H.P.
ORIGINAL DR. BY C.N.H.	DATE: 3-40
REVISED BY C.N.H.	DATE: 12-40
TRACING BY H.H.W.	DATE: 8-42

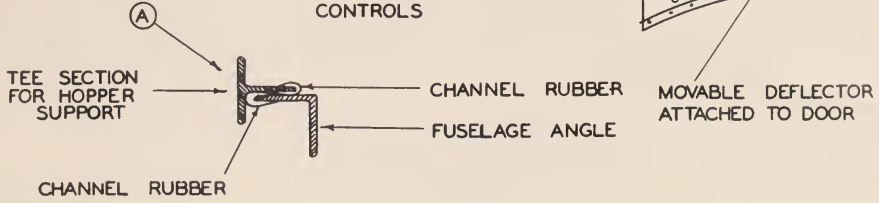
DRAWING NO. 2

LOCATION OF HOPPER



WEIGHTS

HOPPER	78 LBS.
CONVEYOR BOX	60 LBS.
POWER	39 LBS.
VENTURI TUBE	8 LBS.
CONTROLS	7 LBS.
TOTAL	192 LBS.



CROSS SECTION VIEW

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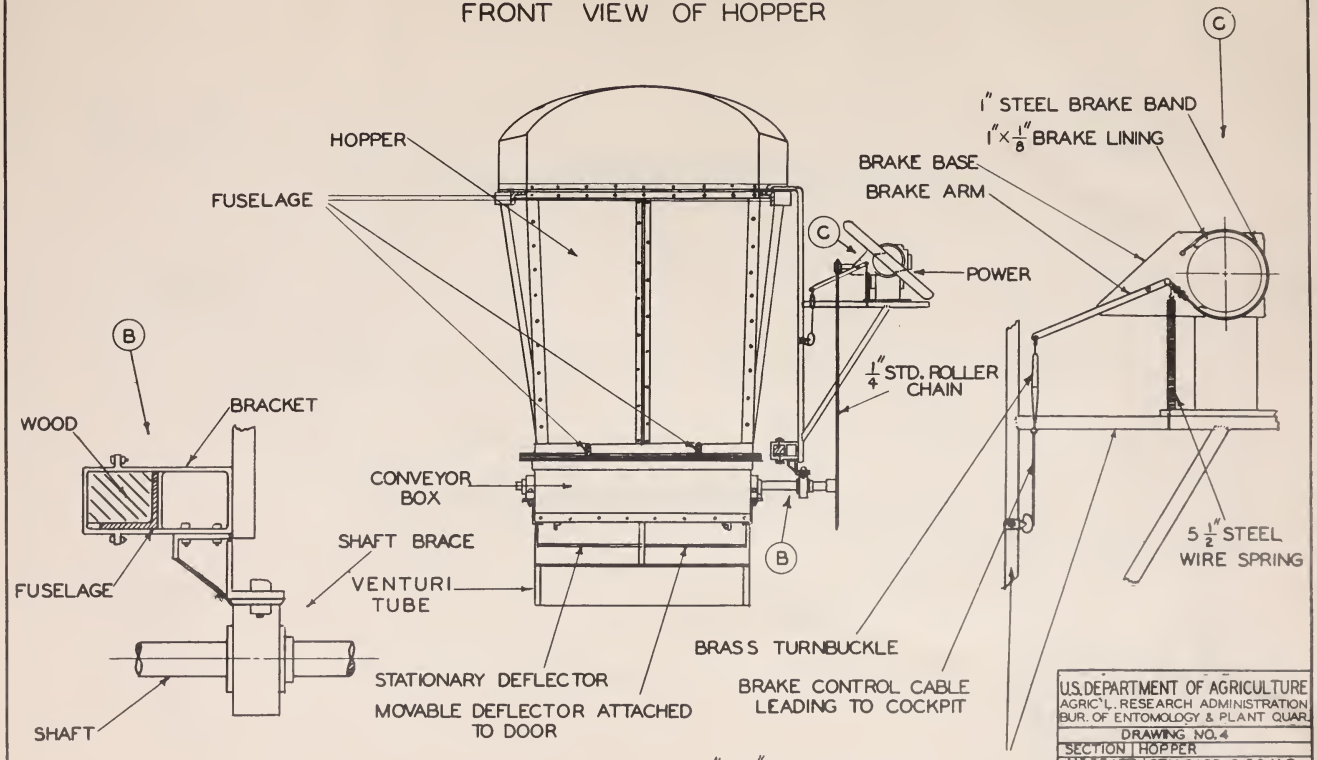
DRAWING NO. 3	
SECTION	LOCATION OF HOPPER
AIRCRAFT	STANDARD 285 H.P.
ORIGINAL DR. BY C.N.H.	DATE: 3-40
REVISED BY C.N.H.	DATE: 12-40
TRACING BY H.H.W.	DATE: 8-42

FRONT VIEW OF HOPPER



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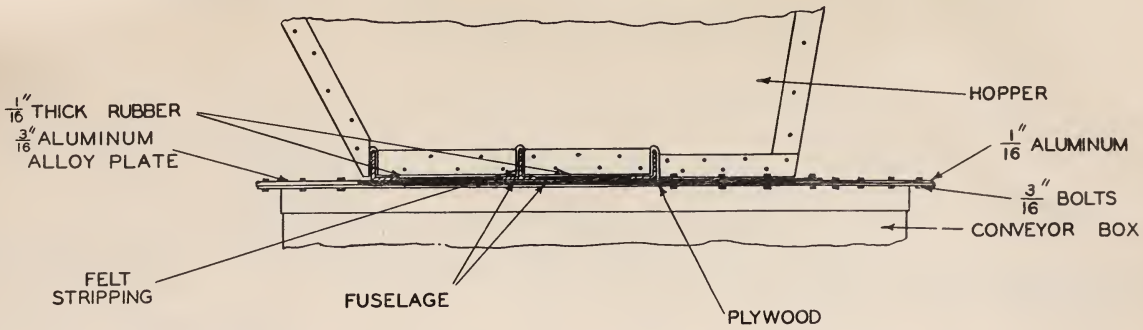
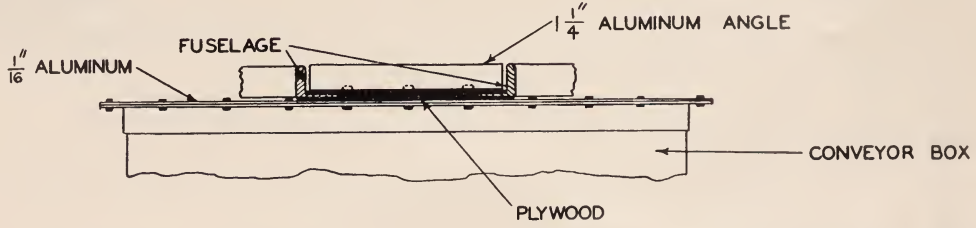
DRAWING NO. 4	
SECTION	HOPPER
AIRCRAFT	STANDARD 2 85 H.P.
ORIGINAL	DR. BY C.N.H. DATE: 3-40
REVISED BY C.N.H.	DATE: 12-40
TRACING BY H.H.W.	DATE: 8-42

SIDE VIEW OF FASTENING OF CONVEYOR BOX TO HOPPER



FRONT VIEW OF FASTENING OF CONVEYOR BOX TO FUSELAGE



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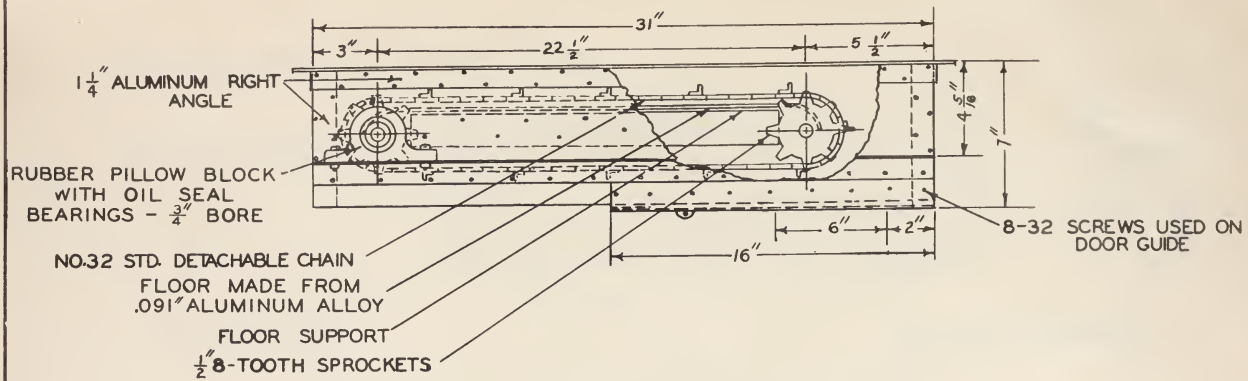
DRAWING NO. 5	
SECTION	FASTENING OF CONV. BOX
AIRCRAFT	STANDARD 285 H.P.
ORIGINAL DR. BY C.N.H.	DATE: 3-40
REVISED BY C.N.H.	DATE: 12-40
TRACING BY H.H.W.	DATE: 8-42

SIDE VIEW OF CONVEYOR BOX



BOX MADE FROM .065″ALUMINUM SHEET

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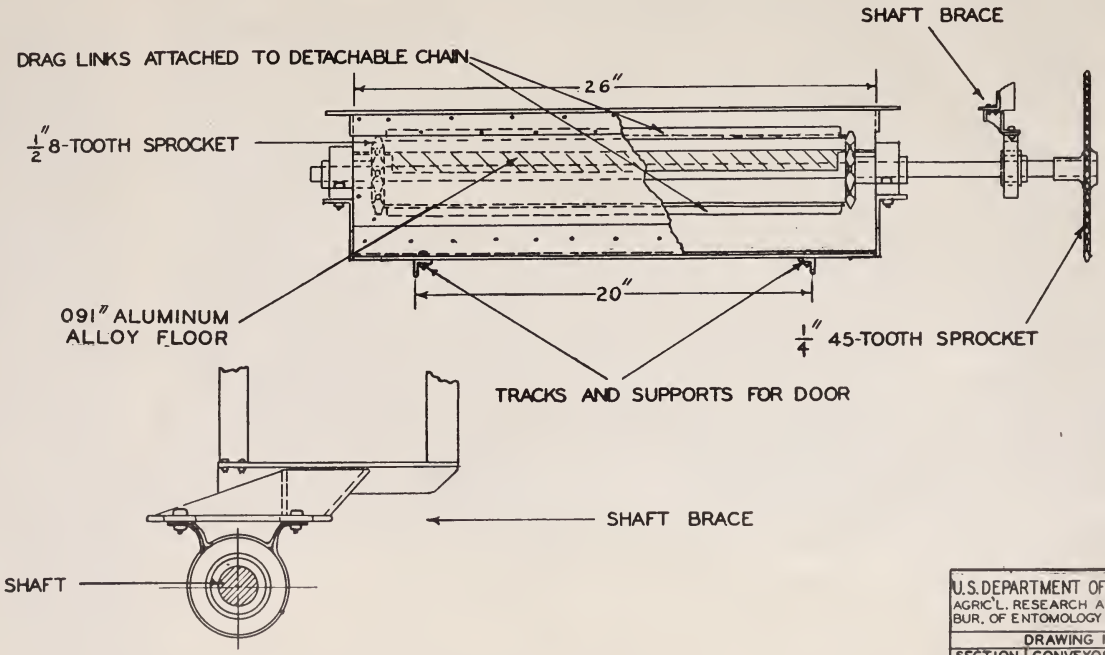
DRAWING NO. 6	
SECTION | CONVEYOR BOX	
AIRCRAFT | STANDARD 285 H.P.	
ORIGINAL DR. BY C.N.H.	DATE: 3-40
REVISED BY C.N.H.	DATE: 12-40
TRACING BY H.H.W.	DATE: 8-42

FRONT VIEW OF CONVEYOR BOX



U.S. DEPARTMENT OF AGRICULTURE AGRIC'L. RESEARCH ADMINISTRATION BUR. OF ENTOMOLOGY & PLANT QUAR.	
DRAWING NO. 7	
SECTION	CONVEYOR BOX
AIRCRAFT	STANDARD 285 H.R
ORIGINAL DR. BY C.N.H.	DATE: 3-40
REVISED BY C.N.H.	DATE: 12-40
TRACING BY H.H.W.	DATE: 8-42